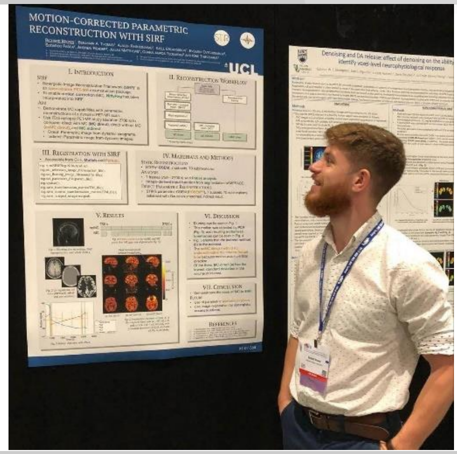
No Motion is *The* Potion for Medical Image Clarity

CoSeC
Computational Science Centre
for Research Communities

Dr. Richard Brown of UCL (University College London) Institute of Nuclear Medicine, and funded by the Computational Collaborative Project Synergistic Image Reconstruction for Biomedical Imaging (CCP SyneRBI), wrote the second placed application for the 2020 CoSeC Impact Award, for his contribution to software that aids clinicians in their diagnoses of patients' medical conditions. Richard joined UCL as a postdoctoral researcher in 2016 and continues to build on the pre-existing software that improves the quality and clarity of medical images.



Background

Two of many possible types of imaging (i.e., modalities) are positron emission tomography (PET) for function, and magnetic resonance (MR) for structure that provide details of a patient's internal system. Bringing together both techniques (PET-MR) makes it possible to build a holistic image of a patient, thereby aiding clinicians in their diagnoses. PET-MR machines have been around for 15 years, but they are quite rare across the world; there are only 10 in the UK, one of which is in the UCLH hospital.

CCP SyneRBI develops specialist software that combines the differently formatted data output from PET and MR scanners. The open source software Synergistic Image Reconstruction Framework (SIRF) combines these two types of data to produce two complementary images.

Although PET-MR machines come with the manufacturer's software, researchers specifically develop open source software to ensure it is available to the wider research community and to prototype new workflows and algorithms.

Before SIRF, the development of PET and MR reconstruction frameworks were typically independent. Now, their combination in an open source format enables a large pool of researchers to contribute to its development, thereby increasing the speed and quality of its evolution that ultimately has greater advantages for patients and their diagnoses.

Challenge

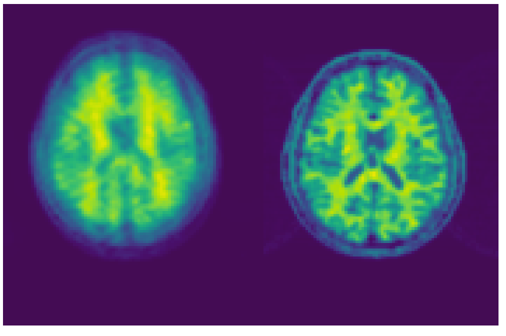
Good quality medical images rely on patients remaining still during their scan. However, this is practically impossible because patients (usually!) need to breathe, on top of which they might have a condition (e.g. epilepsy) that makes it impossible to keep still.

The MR component of PET-MR can be used to build an anatomical image of the patient (i.e., what their body looks like). The PET component measures radiotracer distribution in the body, indicating metabolic processes (i.e., how their body uses certain substances). The resulting images are often displayed as 3D pixels, called voxels, and the combination of the two modalities is then used by clinicians. To best analyse the images, clinicians need clear, blur-free images, which enables a thorough understanding of a patient's condition leading to an accurate diagnosis.

Therefore, it is essential to minimise blur caused by motion.

Richard’s role in addressing the challenge

Richard's research based on SIRF involved correcting the blur caused by epileptic patients’ head motion during a PET-MR scan. Thanks to SIRF, it is now possible to extract the motion from either the PET or the MR images and use these during motion correction.
Richard developed the code (based on Principal Component Analysis) that looks for trends in multi-dimensional, noisy data and simplifies it into a series of 1-D lines in which motion is represented by large spikes. Once it is known when the patient motion occurred, motionless periods can be extracted, and images that are no longer motion-corrupted can be reconstructed.
Motion correction of PET-MR scans of epilepsy patients will help improve diagnosis, as well as putting a useful workflow into place for other motion correction tasks. Future developments of SIRF within CCP SyneRBI include the addition of extra modalities, thereby increasing the range and type of biological image reconstruction – an excellent prognosis for the future of medical diagnosis!



Left: Non-motion corrected image;
right: motion-corrected image

SIRF is an ideal tool both for education and the rapid prototyping of new functionality, and it is easy for users to acquire through its availability via:

- virtual machines,
- Azure instances,
- Docker,
- SuperBuild (building all the required dependencies natively).

It is also easy to use thanks to wrapping the underlying code (C++) into Python and MATLAB (script-style languages).

CoSeC’s Impact

“My role at UCL within CCP SyneRBI includes developing new algorithms and workflows, implementing new code, organising and participating in hackathons, and teaching in workshops, all of which are greatly facilitated by CoSeC members.”

Dr. Richard Brown

CoSeC’s support for a collection of CCPs facilitates the development of SIRF in several ways: CCP SyneRBI and CCPi (CCP-Tomographic Imaging) have a close association that enables software development, the latest instance being a virtual hackathon to extend a CCPi code. Hackathons bring together collaborators spread across the world and are a useful way to get many people interested in the same topic at the same time. This allows participants to tackle a few big issues that are individually challenging, resulting in good progress in a short amount of time. CoSeC members extensively support these hackathons.

https://www.scd.stfc.ac.uk/Pages/CoSeC-Case-Studies.aspx

Further Information

Dr. Brown’s work was funded through the EPSRC grant: EP/P022200/1
Synergistic image reconstruction symposium with many external speakers
Details of the most recent hackathon
More information on this research

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SyneRBI

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